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other hand, no such flood as deposited this gravel has ever occurred within the historical epoch. No such large boulders are ever now carried down the river. No modern rain-storms could cause such a flood. It is difficult to assign any other cause than that of a melting glacier. Yet such a glacier could hardly be the great Northern glacier, for these gravels are much newer than those of the Champlain epoch. There is here evidence of a second and more recent glacier in the Delaware valley.

The hypothesis of a *second glacial epoch* seems to explain all the facts observed. A similar period in Europe—the reindeer period—is supported by many facts. Should such a period not be traced in America, the date of the melting glacier must be made much more recent than that generally assigned.

The relics of man which occur in the Trenton gravel, and which were first found by Dr. C. C. Abbott, are of great interest. In shape, in size, in workmanship, and in material the implements here found are quite different from those used by the Red Indian. These “palæoliths” are imbedded at various depths in undisturbed Trenton gravel. There are two points which offer strong evidence that they are as old as the gravel. The first is the fact that modern Indian implements (“neoliths”), although abundant on the surface, never occur more than a few inches below it, and are never associated with the palæoliths, which are found at depths of from five to forty feet below the surface. This fact alone argues a different age for the two classes of implements. The second fact is that, when found below the surface, the palæoliths always occur in the Trenton gravel and never in older gravels. The writer has gone over, with Dr. Abbott, much of the ground where the implements occur, and it was very interesting to find that it was only within the limits of the Trenton gravel, previously traced out by the writer, that Dr. Abbot had found implements below the surface. Here, then, is the strongest probability, even if the implements were found on the surface only, that they belonged to and were of co-eval deposition with the river gravel.

The implements found in the river gravels of Europe are of similar type, though as a rule perhaps less rude. It is of interest to find that very similar implements have been used by the Eskimos, and it is probable that that race, now living in a climate and under conditions perhaps similar to those once existing in the Delaware, may have some kinship with the pre-Indian people of this river. The occurrence of bones of arctic animals in the Trenton gravel indicates a period of cold.

All the evidence now gathered points to the fact that at the time of the Trenton gravel flood, man, in a rude state, lived upon the ancient banks of the Delaware. If future archæological work can show a connection between this people and the Eskimos, it may be appropriate to call the period of the Trenton gravel and of this palæolithic people—a period perhaps following a second glacial age—the *Eskimo period*, a name more suggestive, and derived from a higher order of beings than that which gave the name “Reindeer Period.”

While others have held that the occurrence of implements in the Trenton gravel indicates the existence of man in inter-glacial or even pre-glacial times, the writer believes that the investigations here described indicate the origin of man, at a time which geologically considered, is recent. Neither in the Champlain deposits, in the morainic material of the north, or in any older gravels have undoubted traces of man been discovered.

The actual age of the Trenton gravel, and the consequent antiquity of man in the Delaware, cannot be determined by geological data alone. It is the aim of this paper to define man's antiquity in relation to geological rather than to historical events. If, in showing that the Eskimo period is the last of the geological ages, it does not necessarily follow that it is by any means recent; it must be remembered, on the other hand, that its high antiquity is not proven by the facts thus far observed.

The conclusions to which the facts seem to point are briefly summarized as follows:

1. That the Trenton gravel, the only gravel in which implements occur, is a true river deposit of post-glacial age, and the most recent of all the gravels of the Delaware valley.

2. That the palæoliths found in it really belong to and are a part of the gravel, and that they indicate the existence of man in a rude state at a time when the flooded river flowed on top of this gravel.

3. That the data obtained does not necessarily prove, geologically considered, a vast antiquity of man in Eastern America.

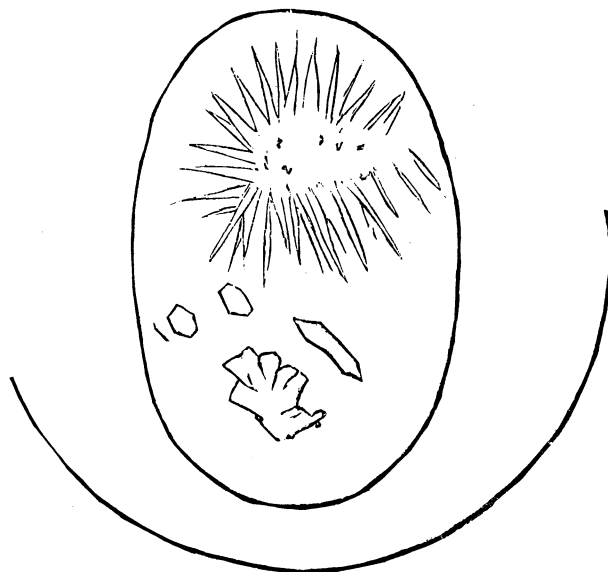
PYROLOGY, AND MICROSCOPICAL CHEMISTRY.

By W. A. ROSS, LT. COLONEL, LATE R. A.

(1). In the year 1869, at Simla, India, having applied a trace of oxide of cobalt to a bead of boric acid before the blowpipe, I observed that, instead of dissolving, as I had been led to expect, small round black spots were formed, which, appearing perfectly round through the clear bead from every point of view, seemed to be spherules or balls. It was afterwards found that 14 oxides form such balls in boric acid, B. B., among which the most useful pyrological was that of *calcium*.

(2). I found, by the average of five assays, that the weight of the calcium borate ball, extracted by boiling water in which it is utterly insoluble, while the containing bead is rapidly dissolved—was a *constant multiple* of the weight of the calcined lime taken to make it, and that this multiple was 4.5. Thus, if w = the weight of the ball, the formula $\frac{w}{4.5}$ represented the quantity of pure lime in it. If *calcium hydrate* was taken, instead of calcined lime, a clear ball was still formed within the bead, which latter became opaque through opalescence, and as the balance showed that this ball also contained the above mentioned proportion of calcined lime, the opalescence was attributed to chemical water.

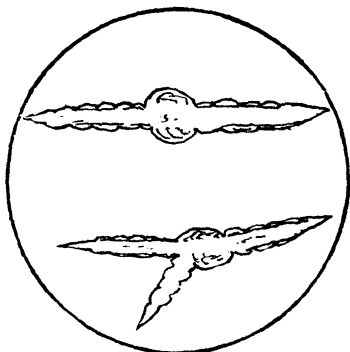
(3). Circumstances of a painful nature, which I need not here relate, prevented my going further into this matter for eight years, but I vainly solicited the Microscopical Society to take it up, and having been enabled this year (about two months ago) to purchase a binocular microscope, with polariscopic apparatus attached, I fitted a small spectro-scope I had by me into one of its eye-pieces with cotton wool, etc., and renewed my examination of these boric acid balls.



TIN BORATE, (POLARIZED).

(4). Notwithstanding the undoubtedly chemical nature of the combination I have called “a calcium borate ball,” the phenomenon of ball formation itself is obviously as much related to the subject of molecular physics as to chemistry, and seems explainable briefly as follows: All liquids having cohesion have, under circumstances of equilibrium,

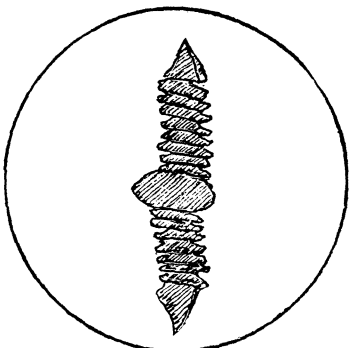
a tendency to take the globular form, because it is the form in which the particles are at the least mean distance from the centre of gravity. As most oxides do not dissolve in boric acid, if the latter in its viscous state has very nearly the same specific gravity as the fused oxide, but is not miscible with it. This forms a ball with a tendency to occupy the centre of the bead, as oil does in water or water in oil, and the microscope now showed me, with reference to silica, that what I had supposed, looking through an ordinary lens, to be siliceous crystals adhering to calcium borate balls, formed by the mineral *Wollastonite* in boric acid were, in reality, thousands of *inner* transparent balls floating inside each calcium borate ball.



TUNGSTONE BORATE.

Similarly, therefore, it may be assumed, that a second borate, if it is not miscible with the first borate, but if it has a stronger cohesion, will take the place of an inner bead, and so it may be presumed with a succession of oxides.

(5.) This assumption however demands the concession that each inner ball is a *single* borate, notwithstanding that it must obviously derive its boric acid from the containing borate ball, which, being ascertained, as in the case of calcium, to possess only its definite proportion of that acid, must in that case take the exact proportion of boric acid from the outer bead, which it has to give up to the inner ball.

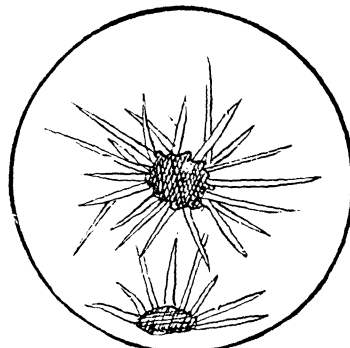


TUNGSTONE BORATE.

(6.) To determine therefore, by actual experiment, if the inner ball in the case of *Wollastonite* was a silico-borate of calcium or a simple borate, I made a *large* calcium-borate ball with pure eggshell lime, in a bead of boric acid; extracted it by boiling the bead in water; made a bead on new platinum wire with the extracted ball; and, applying pure silica to it before the blowpipe, found that it would *not* now form balls within the calcium borate, although it would do so readily enough when the whole was surrounded by a bead of boric acid. On the contrary silica, zirconia, yttria, glucina, alumina, etc—all the “earths” in fact, which will not form balls *per se* in boric acid, dissolve rapidly and transparently in calcium borate when held as a bead by itself on platinum wire, but form balls within it when the whole is surrounded by a bead of boric acid, so that I sub-

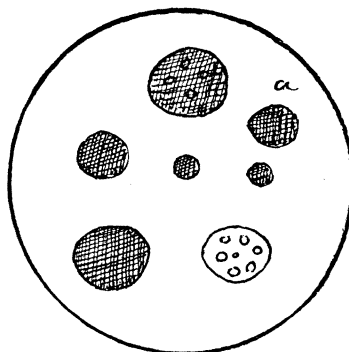
mit the conclusion, that as regards silicate of lime, the inner balls may be composed of a new substance. SILICON BORATE, or alternatively silicate of boron.

(7.) I found that, as in the case of calcium hydrate (2) silica, however chemically pure, invariably gave off a certain amount of matter which caused opalescence in the boric-acid bead, *before* forming the inner balls above mentioned, from which phenomenon I argue that, if silicon borate is presumed to be formed, it is reasonable to infer that what we call silica is in reality *silicon hydrate*, and that a regular chemical interchange of components takes place.



TITANIUM BORATE.

(8.) Alongside the inner “silicon borate” balls in the large calcium borate balls afforded by the mineral *Wollastonite* (from a Freibourg Cabinet) in a bead of boric acid, are numerous spherical enclosures, exhibiting under a $\frac{1}{4}$ -inch objective, a brownish amethystine color, similar to that imparted by manganese to borax held in an oxidising flame, and, on referring to the account of this mineral in Dana's “System of Mineralogy, 1877,” I find that from .2 to .9 of manganic dioxide are supposed to have been detected in certain specimens by Stromeyer, Weidling, and Whitney. But manganese itself forms balls *per se* in a bead of boric acid, and in *no* case, within my observation, do ball-forming oxides produce these *inner* balls in calcium-borate; indeed, from the ordinary law of physics, such a circumstance is an impossibility, and I have mounted boric acid beads of the single colored balls derived from manganese dioxide, and manganese silicate with lime, beside a bead containing the triply-enclosed colored balls derived from *Wollastonite*, which I would submit therefore, may be due to a NEW EARTH of the silica type.

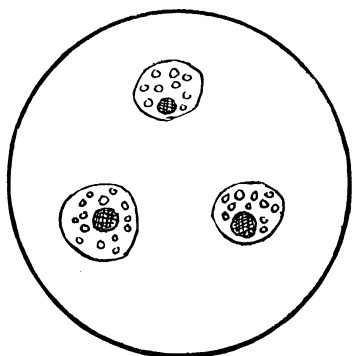


MANGANESE CALCIUM BORATE.

a. Manganese Borate—one Calcium Borate Ball accidentally present

(9.) I would only add here that the acid oxides, as WO_3 , TiO_2 , etc., which also fail to form balls *per se*, in boric acid, remaining there before the blowpipe in *fragments*, colored or not, as the case may be, form, instead of inner balls in

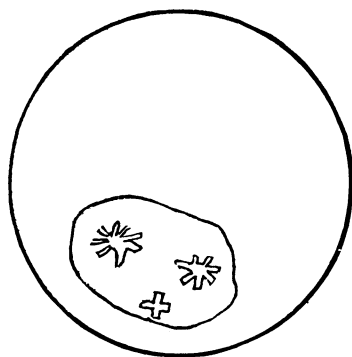
calcium borate, inner crystals, some of which are very beautiful and characteristic, especially by polarised light.



SILICON BORATE.

(10). I now feel that it was necessary to confirm these qualitative experiments by quantitative ones, and to establish the existence of this new substance, whatever it may be, which, eliminated from calcium hydrate, causes *opalescence* in a bead of boric acid before the blowpipe without at all lessening the due proportion of calcium in the borate ball formed—upon the reliable authority of the balance.

(11). As I invariably found that *pure chemically prepared silica* from Dr. Schuchardt, of Görlitz in Prussia, affords *per se* an orange flame before the blowpipe, and opalescence to a bead of boric acid containing a calcium borate ball (7); I chose this single substance, as left by the best analytical chemists in Europe to see if I could not resolve it—by *weighing* them—into two substances, and I submit that the results (the truth of which any chemist may easily ascertain for himself in his own laboratory by simply repeating these experiments) are sufficiently constant, under varying conditions, to warrant the immediate consideration of the unbigoted chemist.



URANIUM BORATE.

I. DR. SCHUCHARTT'S SILICA FROM GÖRLITZ.

	Mqrs.
(1). Si O ₂ dissolved in a calcium borate ball, B. B.	2.5
(2). Weight of siliceous ball	18.5
(3). Weight of siliceous ball after extraction from 1st bead (2)	30.0
(4). Weight of siliceous ball after extraction from 3d bead	26.7
(5). Weight of siliceous ball after extraction from 5th bead, when no more opalescence was given off.	23.0

II. POWDER OF PURE ROCK CRYSTAL.

(1). Si O ₂ dissolved in a calcium borate ball, B. B.	2.5
(2). Weight of siliceous ball	22.3
(3). Weight of siliceous ball after extraction from 1st bead	30.7

(4). Weight of siliceous ball after extraction from 4th bead	27.8
(5). Weight of siliceous ball after extraction from 5th bead	24.8

III. THE SAME AS ABOVE.

(1). Si O ₂ dissolved in a calcium borate ball	2.5
(2). Weight of siliceous ball	29.0
(3). Weight of siliceous ball after extraction from 1st bead	38.5
(4). Weight of siliceous ball after extraction from 5th bead	34.1

IV. MEXICAN OPAL (nearly transparent).

(1). Si O ₂ dissolved in calcium borate ball	2.5
(2). Weight of siliceous ball	25.8
(3). Weight of siliceous ball after extraction from 1st bead	37.5
(4). Weight of siliceous ball after extraction from 3d bead	33.5
(5). Weight of siliceous ball after extraction from 6th bead	28.8

V. MEXICAN OPAL (again).

(1). Si O ₂ dissolved in calcium borate ball	2.5
(2). Weight of siliceous ball	18.0
(3). Weight of siliceous ball after extraction from 1st bead	30.0
(4). Weight of siliceous ball after extraction from 4th bead	28.5
(5). Weight of siliceous ball after extraction from 5th bead	26.9

INCREASE OF WEIGHT.

Experiment I.

Operation (5) — (2) = 23 — 18.5 = 4.5.	Mqrs. Mqrs. Mqrs.
Weight of Opalescent Matter = (3) — (5) = 30 — 23 = 7.	Mqrs. Mqrs. Mqrs.

Experiment II.

Operation (5) — (2) = 24.8 — 22.3 = 2.5.	Mqrs. Mqrs. Mqrs.
Weight of Opalescent Matter = (3) — (5) = 30.7 — 24.8 = 5.9	Mqrs. Mqrs. Mqrs.

Experiment III.

Operation (4) — (2) = 34.1 — 29.0 = 5.1.	Mqrs. Mqrs. Mqrs.
Weight of Opalescent Matter = (3) — (4) = 38.5 — 34.1 = 4.4.	Mqrs. Mqrs. Mqrs.

Experiment IV.

Operation (5) — (2) = 28.8 — 25.8 = 3.0.	Mqrs. Mqrs. Mqrs.
Weight of Opalescent Matter = (3) — (5) = 37.5 — 23.8 = 13.7.	Mqrs. Mqrs. Mqrs.

Experiment V.

Operation (5) — (2) = 26.9 — 18.0 = 8.9.	Mqrs. Mqrs. Mqrs.
Weight of Opalescent Matter = (3) — (5) = 30.0 — 26.9 = 3.1.	Mqrs. Mqrs. Mqrs.

NOTE.—The illustrations accompanying this article are made from rough sketches of crystals drawn, without camera luada from the microscopes. The shaded parts indicate color. The crystals were made by dissolving the oxide BB in a calcium borate ball held as a bead on platinum wire; crushing this bead to powder, and applying some of this powder BB to a boric acid bead.*

Mr. Barkas, of Newcastle-on-Tyne, Eng., has taken a very practical method of encouraging observational Astronomy, by offering to meet any of his townsmen who may be sufficiently interested and show them Jupiter, Saturn and other objects through an excellent telescope. From small beginnings great things often arise, and we should not be surprised if this offer, to be at a certain spot on a given night, led to the establishment of an observing society in Newcastle.

* In forwarding the above communication to "SCIENCE," Col. Ross states that it was originally prepared to be read at the recent meeting of the British Association.—(ED.)